Johnson Space Center
Procedural
Requirements

JPR No.:	1700.1J, Change 1
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Verify that this is the correct version before use

Compliance is Mandatory

JSC SAFETY AND HEALTH HANDBOOK

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Change Record for JPR 1700.1, "JSC for Safety and Health Handbook"
(Baseline – Revision G)

Change . .	*Date . . .*	*Originator…*	*Chapters affected . . .*	*Description of change . . .*
Change 1 to Rev G	11/14/97	D. L. Clem, extention 34272	106 203 505	Adds process for reporting international mishaps Removes requirement for bicycle helmets Updates lifting requirements
Editorial	7/10/98	D. L. Clem, extention 34272	Preface	Revises JSC Safety Policy per ESC direction
Change 2 to Rev G	8/6/98	D. L. Clem, extention 34272	114	Updates safety committee structure Changes time to serve on committees and allows for volunteer members
Revision H	2/3/99	D. L. Clem, extention 34272	Entire Document	Includes upgrades from comparing JPG 1700.1 with NASA requirements Includes upgrades from comparing JPG 1700.1 with 29 CFR 1960 requirements Includes upgrades from comparing JPG 1700.1 with VPP and PEP requirements Includes other changes suggested by various JSC organizations
Change 1 to Rev H (Editorial Included in hard copies)	3/99	D. L. Clem, extention 34272	100 101 108 309	Update URL to on- line version and paragraph 5 Include JSC Safety Policy and rearrange chapter Update cross references Clarify "enough time" to "3 - 5 days before TRR"
Editorial	7/2000	D. L. Clem, extention 34272	Subject Index	Changed "Job Safety Analysis" to "Job Hazard Analysis" to be consistent with Chapter 111.
Revision I	7/2002	D. L. Clem, extention 34272	Entire document	Reorganizes program requirements around VPP elements. New Lockout/Tagout and Chemical alarm chapters. Updates to other chapters.
Change 1 to Rev I	11/7/02	D. L. Clem, extention 34272	3.6 5.1 5.2 6.8 7.3 Glossary 2.7, 6.8, 6.10, 8.1, 9.3, and Attachment 3.6A – Appendix 3B	Changes to medical exam requirements. Clarifies storage requirements. Clarifies requirements for space heaters New safe work practices and design requirements. Added responsibility for radiation equipment. Changed Oxygen Enriched Atmosphere definition. Clarifies emergency number for the Sonny Carter Training Facility.

Verify this is the correct version before you use it by checking the on-line version.

Change 2 to Rev I	5/11/04	D. L. Clem, extention 34272	5.7	Changes to accommodate new Part 12
			Part 12	Adds new Asbestos Control Requirements. This is a revision of the Asbestos Control Manual
Change 3 to Rev I	6/2/05	D. L. Clem, extention 34272	Document number	Changed number to JPR 1700.1
			5.9	New chapter on Weather Safety
			6.1	Updates emergency eyewash & shower reqmts
			6.5	Updates emergency eyewash & shower reqmts
			6.8	Updates emergency eyewash & shower reqmts
			6.13	New chapter on breathing gases
			8.5 & Appendix 5B	Adds inspection program for forklifts & slings, eliminates duplicate requirements
			8.6	Adds inspection program for power tools
			8.7	Adds inspection program for ladders
			9.1	Updates several hazardous material requirements
			9.2	Updates several hazardous material requirements
			10.1	Updates emergency eyewash & shower reqmts
			12.1 and Part 12	Clarifies applicability to JSC field sites
				Removes advisory language and updates organizational titles & document numbers in several other chapters

Change 4 to Rev I	9/25/06	D. L. Clem, extention 34272	2.4	Adds reference to NASA Facility System Safety Guidebook.
			2.7	Updates mishap investigation products to reference NASA mishap reporting and investigation requirements.
			5.2	
			6.1	Adds requirement not to wear jewelry during maintenance or troubleshooting on any electrical or mechanical system.
			6.4	
			6.11	Revises processes for handling and disposing of batteries.
			6.13	Revises food safety requirements.
			10.1	Adds a requirement to test oxygen and oxygen enriched gas systems with oxygen or oxygen-enriched gas before introducing a human into the loop.
			10.3	Adds requirement to allow the Safety and Test Operations Division to waive cleanliness requirements.
			11.2	Adds construction safety requirements as a result of a mishap investigation and updates requirements for construction barriers.
			Glossary	Adds provisions for a less-rigorous Use Readiness Review.
			Several	Adds requirements for construction contracts as a result of a mishap investigation.
				Updates the definition of "oxygen enriched" consistent with the changes to Chapter 6.11.

Change 5 to Rev I	1/12/07	D. L. Clem, extention 34272	8.2 Appendix 8B	Temporary change via JSC Announcement to update Lockout/Tagout requirements pending a complete revision of JPR 1700.1. Also deletes Attachment 8.2A and revises Attachment 8.2B of Appendix 8B.
Revision J	4/16/08	D. L. Clem, extention 34272	Entire Document	Complete revision to several chapters.
Change 1 to Rev J	xx/yy/09	D. L. Clem, extention 34272	Chapter 5.6	Update process for getting prescription safety glasses.
			Chapter 6.2	Updates to laser safety consistent with higher level requirements.
			Chapter 6.6	Make physical exam requirements consistent with chapter 3.6.
			Chapter 6.11	Update to gas cylinder requirements.

JSC Directives System Procedural Requirements

Preface

Title: JSC Safety and Health Handbook

P1. Purpose

This document defines JSC's Safety and Health Program and provides basic safety and health requirements for the Johnson Space Center (JSC) and for other locations under JSC's jurisdiction. It is important that you follow the safety and health requirements that apply to your job.

P2. Applicability

This handbook applies to anyone at JSC or JSC field sites, unless exempted in a specific chapter. For this handbook, "JSC" includes all JSC sites in the Houston area such as Ellington Field and the Sonny Carter Training Facility. The handbook applies to operations involving JSC personnel or equipment at non-JSC locations, including foreign countries. See Chapter 1.4, paragraph 6, for more information on following standards at non-JSC locations.

a. The following table tells you who must follow this handbook.

If you . . .	***Then you shall follow . . .***
Are a federal employee	This handbook unless you work at a site that involves unique military equipment and operations
Are a JSC contractor	This handbook as called out in your contract. Prime contractors must flow down these requirements to subcontractors
Work at a JSC remote site (such as White Sands Test Facility) as a civil service employee or contractor employee	All chapters that don't exempt you and local requirements that meet the intent of any chapter that exempts you If a chapter exempts you, develop your own requirements that meet the intent of that chapter The local Quality Assurance, Reliability, and Safety Office or equivalent carries out the responsibilities of the Safety and Test Operations Division at your site
Are a non-NASA or non-contract employee	This handbook while you are on JSC property

b. If you are a federal employee working in a private employer's facility, you are covered by the JSC safety and health program. Although NASA may not have the authority to correct hazardous conditions in a private sector workplace, NASA makes sure your working conditions are safe and healthful. NASA does this by administrative controls or personal protective equipment, or your withdrawal from the private employer's facility.

c. If you are a private employer, neither Executive Order 12196, "Occupational Safety and Health Programs for Federal Employees," nor this handbook relieves you or your employees of any rights or responsibilities under the Occupational Safety and Health Administration (OSHA).

P3. Authority

a. NPD 8710.2, "NASA Safety and Health Program Policy"

b. NPR 8715.1, "NASA Occupational Safety and Health Programs"

c. NPR 8715.3, "NASA General Safety Program Requirements"

d. Executive Order 12196, dated February 26, 1980, "Occupational Safety and Health Programs for Federal Employees," (3 CFR 1980 Compilation)

e. 29 Code of Federal Regulations, Part 1960, "Basic Program Elements for Federal Employee Occupational Safety and Health Programs and Related Matters"

P4. References

a. OSHA Instruction TED 8.4, "Voluntary Protection Programs (VPP) Policies and Procedures Manual"

b. 29 Code of Federal Regulations, Part 1910, "Occupational Safety and Health Standards"

c. NPD 1800.2, "NASA Occupational Health Program"

d. NPD 1810.2, "NASA Occupational Medicine Program"

e. NPD 1820.1, "NASA Environmental Health Program"

P5. Cancellation

This handbook replaces JPR 1700.1I.

Chapter 5.6
Personal protective equipment

This could be you . . .

An employee accidentally cut into a chemical line and some of the chemical splashed on the particulate respirator he was wearing. He suffered throat irritation and coughing because the particulate respirator wasn't designed to protect against the chemical.

An employee who wasn't wearing a hard hat hit his head on a pipe and fell to the floor.

1. Applicability of this chapter

You are required to follow this chapter if you use personal protective equipment (PPE) in your work.

2. What this chapter covers

This chapter covers the selection, use, and maintenance of PPE. You can find specific requirements for respirators, hearing conservation, and asbestos in Chapter 7.2, "Respiratory protection," Chapter 7.1, "Hearing Conservation," and Part 12 of this Handbook, "Asbestos Control Requirements."

3. When you need PPE

You need to use PPE when you work in hazardous situations where engineering controls, management controls, or other corrective actions do not reduce the hazard to an acceptable level. The Safety and Test Operations Division and the Occupational Health Branch along with your supervisor will determine the need for and selection of PPE based on the hazards in your work area. The process is as follows:

a. Your supervisor or company shall do a hazard assessment on your need for PPE and verify the assessment in writing. Include this assessment in your facility's safety and health documentation.

b. The written verification shall state that it certifies that the assessment has been done and includes the following:

- Workplace location.
- The date of the hazard assessment (Job Hazard Analysis).
- The person who certifies that the evaluation has been done.

4. How you get PPE

Your supervisor (for civil service employees) or company (for contractor employees) is responsible for providing PPE. If you are a transient employee or a visitor, your host organization is responsible for providing PPE.

Where allowed by contract, you may obtain rigid frame prescription safety spectacles by completing a JSC Form 557 along with an ~~current (no more than 90 days old)~~ eye prescription issued within the last year. ~~and bring it to the Occupational Health Branch, 281-483-4317~~. On the form, state that you work in an eye hazard area, and list your duties and specific hazards that require safety glasses. Have the form approved by your supervisor and the organization's safety representative and bring it to the Occupational Health Branch, 281-483-4317. You pay for any eye exams. Prescription safety glasses are provided at the maximum frequency of one pair every two years unless the current pair has been lost or damaged.

See NPR 4100.1, "NASA Materials Management Manual," for requirements for stocking and issuing PPE.

5. Providing and using your own PPE

You shall only use PPE recommended and provided by your employer.

6. How to select PPE

Select PPE based on a hazard assessment (Job Hazard Analysis) that your supervisor performs. He or she will let you know what hazards are found and what PPE is required. You shall select PPE that will fit you properly. PPE selection factors include:

a. Exposure potential to hazard, including frequency and length of contact.

b. Potential effects of skin contact with the hazard.

c. The body part that could be exposed, such as hands, face, chest, arms, etc.

d. The protection factor of the PPE.

e. Other safety hazards present such as falling, slipping, falling objects, electrical shock, etc., and the hazards that may be induced by wearing the PPE.

f. Limitations caused by the PPE, such as reduction in sight, hearing, or touch.

g. Work area conditions such as temperature, humidity, abrasion, and cutting or tearing potential.

h. Characteristics and limitations of the PPE such as resistance to degradation, size, comfort, and dexterity.

i. Anticipated use (single use vs. routine use, duration of use).

j. Regulatory requirements. Use only PPE that is approved.

k. PPE service life and cost.

NOTE: Help in selecting your PPE is available from the Safety and Test Operations Division for potentially hazardous physical or mechanical hazards and from the Occupational Health Branch for potentially hazardous chemical and biological agents.

7. Precautions to take when working around physical hazards

You shall observe the following requirements when working around physical hazards:

a. Wear flame-retardant clothing when operations involve the possibility of explosion or fire.

b. Wear protective gloves made of strong, durable material when operations include handling sharp-edged or abrasive objects.

c. Wear gloves made of thermal protective material when handling hot or cryogenic substances.

d. Wear gloves made of rubber or other nonconductive material that conform to the OSHA standard for dielectric strength when operations include potential exposure to electrical current.

e. Wear hearing protection in hazardous noise areas.

f. Wear hard hats when there is a potential for injury to the head from falling objects.

g. Wear eye and face protection when there is a potential for injury from flying particles, chemicals, or laser radiation.

8. Precautions to take when working around chemical and biological hazards

You shall wear protective clothing when working with hazardous chemical and biological agents and when required by the EPA, Centers for Disease Control and Prevention, or OSHA standards. Base the selection of protective clothing on the environment in which it will be used. The section of the material safety data sheet marked "Exposure Controls and/or Personal Protective Equipment" will give you specific instructions on PPE for the material you're using. Use the following key points when selecting protective clothing:

a. All chemicals pass or permeate through protective barriers sooner or later, with or without any visible evidence or change in the protective materials.

b. A material may protect against one chemical very well but perform poorly against another chemical. Each chemical and material combination shall be considered. No single protective material is an absolute barrier against all chemicals.

c. Protective gloves and other chemical protective clothing may all look alike. Make sure that the clothing you select is the right clothing for the job that you are doing.

d. When a chemical is absorbed by protective clothing material, it will continue to pass through the material.

e. Chapter 7.4 provides information on PPE and precautions to be used when handling biohazards.

9. Precautions to take when working where head protection is required

You shall observe the following requirements if you are exposed to head hazards:

a. Wear a well-fitting hard hat that meets 29 CFR 1910.135, "Head Protection," and ANSI specifications in ANSI Z89.1, "Industrial Head Protection."

b. Sanitize the shell and replace or sterilize the cradle and sweatband before giving your hard hat to another worker.

c. Replace the cradle and sweatband to maintain the effectiveness of the hard hat. Replace them on a regular schedule as recommended by the manufacturer.

d. Clean the shells with a mild soap and water. Never use solvents or abrasives.

e. Wear a Class A or Class B hard hat around electrical hazards.

f. Store hard hats away from ultraviolet rays.

g. Don't drill holes in your hard hat to attach things unless your hard hat is designed to accommodate holes.

10. Precautions to take when working where eye protection is required

You shall observe the following requirements when working in eye hazard areas:

a. Wear side shields on your safety glasses when there is a hazard from flying objects.

b. If you wear corrective lenses in spectacles, use one of the following types of eye protection:

   1. Goggles worn over the protective lenses
   2. ANSI-approved safety eyewear

c. Observe the following policy for wearing contact lenses:

   1. You may wear contact lenses if allowed by a workplace or task eye injury hazard evaluation. You need to request this evaluation through your supervisor and it will be conducted by Occupational Health Department (OHD). The OHD will identify chemical exposures (as required by 29 CFR 1910.132), and appropriate eye and face protection for contact lens wearers.
   2. Follow current OSHA regulations on contact lens wear and eye and face protection.
   3. In the event of a chemical exposure, begin eye irrigation immediately and remove contact lenses as soon as practical.
   4. Remove contact lenses at the first sign of eye redness or irritation.

5. You shall never wear contact lenses when exposed to hazardous heat, radiation, and high-dust or high-particulate environments. The NIOSH Current Intelligence Bulletin 59 (http://www.cdc.gov/niosh/docs/2005-139/pdfs/2005-139.pdf) provides recommendations about contact lens use in a chemical environment.

d. Wear goggles when handling corrosive liquids, such as acids and caustics. Make sure the goggles:
   1. Have soft, nonflammable eyecups.
   2. Are flexible enough to fit your face readily.
   3. Are made so that no splashing liquid can get in your eyes through the ventilation openings.

e. Wear goggles when exposed to vapors or fumes that could cause injury or discomfort to your eyes. Make sure the goggles have eyecups that fit your face snugly and have no ventilation openings.

f. Wear goggles, helmets, and shields with a filter lens that meets ANSI-Z87.1, "Occupational and Educational Eye and Face Protection," when doing arc welding, oxy-acetylene welding, furnace work, or any operation where your eyes are exposed to glare.

g. Wear face masks and shields to protect your face from light impacts, sparks, or chemical splashes. Make sure the mask or shield has a nonflammable transparent visor that is free from scratches or other flaws.

h. Always wear safety glasses or goggles under face shields. Face shields are designed to protect the face, not as primary protection for the eyes.

i. Sanitize goggles and glasses before giving them to another worker. Replace any parts such as elastic headbands that can't be sterilized.

j. When not in use, keep goggles, glasses, and face shields in containers to protect them from damage or scratches and from contamination by oil, grease, or other materials.

11. Precautions to take when working where foot protection is required

You shall observe the following requirements when working where foot protection is required:

a. Wear steel-toed safety shoes that meet the requirements of ANSI Z41.1 where your feet are exposed to falling heavy materials, such as in a materials warehouse or machine shop.

b. Wear footwear made of rubber, specially treated leather, wood, or other suitable corrosion-resisting materials when you handle corrosive liquids such as acids and caustics.

c. Wear snug footwear when handling molten metals or hot or corrosive liquids. Make sure your footwear has no laces that would allow liquids to reach your foot.

d. Wear nonmetallic footwear when working with electricity.

e. Wear high-top leather footwear when working with cryogenics.

12. Precautions to take when working where fall protection is required

You shall use appropriate fall protection devices when working in any area that is 4 feet or more above adjoining surfaces and is unprotected by guardrails. Follow the guidelines below:

a. Use a full body harness whenever practical.

b. Use lifelines, drop lines, lanyards, safety belts, and harnesses only for safeguarding workers. Don't use them for any other purpose. A lifeline shall be able to support a minimum dead weight of 5400 lb (2450 kg) per person applied to the center of the lifeline.

c. Don't reuse a drop line, lanyard, belt, or harness that has been stressed by a worker falling.

d. Securely buckle all harnesses and belts, and wear them tight enough to prevent yourself from slipping out.

e. Secure drop lines and lifelines to fixed anchorages; make sure they are long enough to reach the ground; and use pads over sharp corners. A fixed anchorage shall be able to support a minimum dead weight of 5400 lb (2450 kg) per person.

f. Keep lanyard length as short as the work allows. If possible, don't attach to the lifeline below your waist.

g. Use a body harness and shock-absorbing device in the lanyard system if a long freefall is possible.

h. Make sure you are securely attached to a secondary restraint system when using a boson's chair suspension belt.

13. Precautions to take when inspecting fall protection equipment

You shall observe the following requirements when inspecting fall protection equipment:

a. Don't use safety belts, harnesses, and lanyards that have been impact- or load-tested for safety purposes.

b. Use only sample belts and worn belts or those of doubtful quality for testing. Test them to destruction, if possible, or at least to a 4:1 safety factor of the anticipated load. Keep belts that were used for testing only as samples to help judge the safety of other belts.

c. Observe the following guidelines to inspect fall protection equipment:

   1. Inspect all safety equipment such as belts, harnesses, lanyards, and lines before use.

2. Follow your employer's inspection program. Inspect all safety equipment at least every 6 months, and document the date on the equipment.
3. Use the detailed inspection and maintenance procedures that are published by many safety equipment manufacturers and vendors as a guide.

d. Do all preventive maintenance on schedule. This keeps the equipment ready for use and extends the life of the equipment.

e. Notify your supervisor if you find defective PPE, and don't use it.

14. Precautions to take when working in a confined space

Follow the requirements in Chapter 6.10, "Entering confined spaces," of this Handbook.

15. Using and maintaining PPE

Use the guidelines below to get the most from your PPE:

a. Inspect your PPE before putting it on. Look for:
   1. Imperfect seams and poor closures.
   2. Non-uniform coatings and scratches.
   3. Pinholes, tears, and cracks.
   4. Stiffness and discoloration.

b. Don't use PPE that fails inspection. Put it aside and notify your supervisor.

c. Put your PPE on and inspect it to make sure you have it closed correctly and that it fits snugly but doesn't bind.

d. Inspect your PPE every so often while you work and make sure it is still protecting you. Stop work if your PPE fails. Stop work if you get too hot when wearing chemical protective clothing.

e. Clean and decontaminate your PPE before taking it off. Take off your PPE before leaving the work area.

f. Take off your PPE and store or dispose of it properly.

g. Store your PPE separately from your regular clothing.

h. Make sure you understand the chemical properties of any chemical clothing you reuse so that permeation doesn't occur in storage and you decontaminate it after every use.

i. If you reuse damaged PPE, make sure it is fixed to manufacturer's specifications.

j. Maintain your PPE according to the manufacturer's schedule or to your organization's schedule. Minimize field repairs.

k. Account for PPE as described in NPR 4200.1, "NASA Equipment Management Manual."

16. Training for PPE?

See Chapter 4.5, "Personal Protective Equipment Training," of this Handbook.

17. Where you can get more information on PPE

You can find more information on personal protective equipment in these documents:

a. 29 CFR 1910, Subpart I, "Personal Protective Equipment"

b. *Accident Prevention Manual for Business and Industry: Administration and Programs*, 12th Edition, National Safety Council, Washington, D.C., 2000

c. *Accident Prevention Manual for Business and Industry: Engineering and Technology*, 12th Edition, National Safety Council, Washington, DC, 2000

d. *Chemical Protective Clothing*, J. S. Johnson, ed., American Industrial Hygiene Association, Akron, Ohio, 1990

e. ANSI Z41.1, "Personal Protection—Protective Footwear"

f. ANSI Z87.1, "Occupational and Educational Eye and Face Protection"

g. ANSI Z89.1, "Industrial Head Protection"

18. Responsibilities for PPE

a. As a ***supervisor***, you are responsible for:

1. Surveying, identifying, and documenting all actual and potentially hazardous work areas, job operations, and working conditions where PPE is required.
2. Obtaining the required PPE after review by the Occupational Health Branch and the Safety and Test Operations Division.
3. Making sure everyone is aware of the specific PPE required for his or her work assignment.
4. Making sure your operating procedures reflect PPE requirements.
5. Making sure everyone uses the equipment as directed and maintains it in good condition.

b. As a ***procurement coordinator***, you are responsible for:

1. Processing all requests for PPE.
2. Verifying PPE approvals with the Occupational Health Branch for chemical and biological hazards and the Safety and Test Operations Division for physical and mechanical hazards.

c. The ***Occupational Health Branch*** and the ***Safety and Test Operations Division*** are responsible for:

1. Helping supervisors to determine hazards and the need for PPE.
2. Helping in selecting and approving PPE.
3. Reviewing and monitor JSC's respiratory protection program.
4. Fit-testing, training, and consulting with on-site respirator users.
5. Providing general training on PPE.

Chapter 6.2
Laser safety and health

This could be you . . .

Following safe practices has paid off. JSC has no recorded laser incidents.

1. Applicability of this chapter

You are required to follow this chapter if you operate lasers or supervise anyone who operates lasers. At this time, laser pointers are exempted from the requirements of this chapter. (See JSC Safety Alert 99-009, "Safety Hazards of Laser Pointers.")

2. Laser classes

JSC uses the laser classes in ANSI Z136.1, "American National Standard for Safe Use of Lasers:"

a. Class 1 laser system is: ~~No risk lasers aren't hazardous under normal operating conditions.~~

1. Considered to be incapable of producing damaging radiation levels during operation.
2. Exempt from any control measures or other forms of surveillance.

b. Class 1M laser system is:

1. Considered to be incapable of producing hazardous exposure conditions during normal operation unless the beam is viewed with an optical instrument such as an eye-loupe (diverging beam) or a telescope (collimated beam), and
2. Exempt from any control measures other than to prevent potentially hazardous optically aided viewing; and is exempt from other forms of surveillance.

~~b.~~c. Class 2 laser system is: ~~Low risk lasers are low-power lasers that are dangerous only if you stare at a direct beam for long periods of time.~~

1. Emits in the visible portion of the spectrum (0.4 to 0.7 µm), and
2. Eye protection in normally afforded by the aversion response.

d. Class 2M laser system:

e. Emits in the visible portion of the spectrum (0.4 to 0.7 µm), and
f. Eye protection is normally afforded by the aversion response for unaided viewing.
g. Is potentially hazardous if viewed with certain optical aids.

~~d.~~h. Class 3~~A~~R laser system (medium-power): ~~Moderate risk lasers that are too dangerous to view directly.~~

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1. May be hazardous under some direct and specular reflection viewing condition if the eye is appropriately focused and stable, but the probability of an actual injury is small.
2. This laser will not pose either a fire hazard or diffuse-reflection hazard.
3. **Note: Any laser product previously labeled as a Class 3A product can safely be treated as Class 3R if the beam diameter is less than 7 mm.**

i.

~~e.~~j. Class 3B laser system (medium-power): ~~Moderate-risk lasers that are dangerous if you look at a direct or reflected beam~~ May be hazardous under direct and specular reflection viewing conditions, but is normally not a diffuse reflection or fire hazard.

~~f.~~k. Class 4 laser system (high-power): ~~High-risk lasers could cause eye or skin injuries and fires.~~

1. Is a hazard to the eye and skin from the direct beam, and
2. May pose a diffuse reflection or fire hazard.
3. May also produce laser generated air contaminants (LGAC) and hazardous plasma radiation.

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3. Requirements for working with lasers

You shall follow these requirements when you operate any Class 3R~~A~~, 3B, or 4 lasers:

a. Register all Class 1M, 2M, 3R~~A~~, 3B, and 4 lasers on JSC Form 44B and get approval for use from the JSC Laser Safety Officer (LSO) at (281) 483-6726. The LSO may require that a person who has substantial laser training be designated as the area Laser Safety Officer for your area.

b. Follow ANSI Z136.1, ANSI Z136.2, ANSI Z136.6, 21 CFR 1040.10, "Laser products," and 21 CFR 1040.11, "Specific purposes of laser products."

c. Each Class 1M, 2M, 3R~~A~~, 3B, or 4 laser should~~all~~ have an approved JSC Form 44B from the LSO and the Radiation Safety Committee ~~before you may operate it~~.

d. Each Class 1M, 2M, 3R, 3B, or 4 laser should have an approved JF1023 "Nonionizing Radiation Training & Experience Summary" from the LSO.

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~~d.~~e. If you modify the laser, you shall submit a new JSC Form 44B for LSO approval.

~~e.~~f. Don't operate a laser unless you are certified to do so by the LSO.

~~f.~~g. Know the hazards and hazard controls of each laser you operate. You shall take other precautions if:

1. The target material could vaporize into a toxic substance.
2. The laser uses toxic dyes as a lasing medium.
3. The laser components cause radiation such as x ray, ultraviolet, infrared, or radio frequency.
4. The laser could reflect off a smooth surface; e.g., glass, metal, or glossy paint.

~~g.~~h. Lasers have high-voltage power supplies. Take precautions to avoid being shocked.

~~h.~~i. Operate lasers with a beam stop.

~~i.~~j. Don't exceed the maximum permissible exposure (MPE) values found in ANSI Z136.1.

~~j.~~k. Tell all visitors in your laser area ~~who aren't certified operators~~ what the laser hazards are and what safety requirements they need to follow. Visitors shall also:

1. Be under the direct supervision of at least one certified operator.
2. Wear required protective equipment.

~~k.~~l. Operate Class 3R~~A~~, 3B, and 4 lasers only in areas with:

1. No unplanned reflecting or transmitting surfaces.
2. Emergency lighting fixtures.
3. Standard warning placards as described in ANSI Z136.1.

~~l.~~m. Keep all flammable materials away from laser areas unless specifically authorized by an operations or test plan.

4. Engineering controls for laser hazards

Each laser shall have hazard controls that meet ANSI Z136.1. Use engineering controls as much as possible. Also post a current copy of your operating procedures, when applicable. This table tells you which engineering controls are required for each laser class and when they are required. Next to each control is an ANSI Z136.1 paragraph number that offers more details. See the legend below the table for an explanation of the symbols.

Engineering Control Measure	Laser Class				
	1	2	3A	3B	4
Protective housing (4.3.1)	X	X	X	X	X
Without protective housing (4.3.1.1)	LSO must establish alternative controls				
Interlocks on protective housing (4.3.2)	**	**	**	X	X
Service access panel (4.3.3)	**	**	**	X	X
Key control (4.3.4)	—	—	—	#	X
Viewing portals (4.3.5.1)	—	MPE	MPE	MPE	MPE
Collecting optics (4.3.5.2)	MPE	MPE	MPE	MPE	MPE
Totally open beam path (4.3.6.1)	—	—	—	X NHZ	X NHZ
Limited open beam path (4.3.6.2)	—	—	—	X NHZ	X NHZ
Enclosed beam path (4.3.6.3)	None is required if 4.3.1 and 4.3.2 fulfilled				
Remote interlock connector (4.3.7)	—	—	—	#	X
Beam stop or attenuator (4.3.8)	—	—	—	#	X
Activation warning systems (4.3.9.4)	—	—	—	#	X
Emission delay (4.3.9.1)	—	—	—	—	X
Indoor laser controlled area (4.3.10)	—	—	—	X NHZ	X NHZ
Class 3B laser controlled area (4.3.10.1)	—	—	—	X	—
Class 4 laser controlled area (4.3.10.2)	—	—	—	—	X
Laser outdoor controls (4.3.11)	—	—	—	X NHZ	X NHZ
Laser in navigable airspace (4.3.11.2)	—	—	#	#	#
Temporary laser controlled area (4.3.12)	** MPE	** MPE	** MPE	—	—
Remote firing and monitoring (4.3.13)	—	—	—	—	#
Labels (4.3.14 and 4.3.7)	X	X	X	X	X
Area posting (4.3.9)	—	—	#	X NHZ	X NHZ

LEGEND: X – required; # – recommended; — – not required; ** – required if embedded Class 3B or Class 4; MPE – required if MPE is exceeded; NHZ – nominal hazard zone (NHZ) analysis required; (4.3.5.2) – referenced paragraph from ANSI Z136.1-2000

Engineering Control Measures	Classifications						
	1	1M	2	2M	3R	3B	4
Protective Housing (4.3.1)	X	X	X	X	X	X	X
Without Protective Housing (4.3.1.1)	LSO shall establish Alternative Controls						
Interlocks on Removable Protective Housings (4.3.2)	Δ	Δ	Δ	Δ	Δ	X	X
Service Access Panel (4.3.3)	Δ	Δ	Δ	Δ	Δ	X	X
Key Control (4.3.4)	--	--	--	--	--	●	X
Viewing Windows, Display Screens and Collecting Optics (4.3.5.1)	Assure viewing limited < MPE						
Collecting Optics (4.3.5.2)							
Fully Open Beam Path (4.3.6.1)	--	--	--	--	--	X NHZ	X NHZ
Limited Open Beam Path (4.3.6.2)	--	--	--	--	--	X NHZ	X NHZ
Enclosed Beam Path (4.3.6.3)	None is required if 4.3.1 and 4.3.2 fulfilled.						
Remote Interlock Connector (4.3.7)	--	--	--	--	--	●	X
Beam Stop or Attenuator (4.3.8)	--	--	--	--	--	●	X
Activation Warning Systems (4.3.9.4)	--	--	--	--	--	●	X
Indoor Laser Controlled Area (4.3.10)	--	*	--	*	--	X NHZ	X NHZ
Class 3B Indoor Laser Controlled Area (4.3.10.1)	--	--	--	--	--	X	--NHZ
Class 4 Laser Controlled Area (4.3.10.2)	--	--	--	--	--	--	X
Outdoor Control Measures (4.3.11)	X	* NHZ	X NHZ	* NHZ	X NHZ	X NHZ	X NHZ
Laser in Navigable Airspace (4.3.11.2)	X	* NHZ	X NHZ	* NHZ	X NHZ	X NHZ	X NHZ
Temporary Laser Controlled Area (4.3.12)	Δ MPE	Δ MPE	Δ MPE	Δ MPE	Δ MPE	--	--
Controlled Operation (4.3.13)	--	--	--	--	--	--	●
Equipment Labels (4.3.14 and 4.7)	X	X	X	X	X	X	X
Laser Area Warning Signs and Activation Warnings (4.3.9)	--	--	--	--	●	X NHZ	X NHZ

LEGEND: X Shall

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●	Should
--	No Requirement
Δ	Shall if enclosed Class3B or Class 4
MPE	Shall if MPE is exceeded
NHZ	Nominal Hazard Zone analysis required
*	May apply with use of optical aids

5. Administrative controls for laser hazards

You may use administrative controls instead of or in addition to engineering controls as required by the LSO. Laser hazard controls shall meet ANSI Z136.1. Also post a current copy of your operating procedures, when applicable. This table tells you which administrative controls are required for each laser class and when. See the legend below the table for an explanation of the symbols.

~~Administrative Control Measures~~	~~Laser Class~~				
	~~*1*~~	~~*2*~~	~~*3A*~~	~~*3B*~~	~~*4*~~
~~Standard operating procedures (4.4.1)~~	~~—~~	~~—~~	~~—~~	~~#~~	~~X~~
~~Output emission limitations (4.4.2)~~	~~—~~	~~—~~	~~LSO determines~~		
~~Education and training (4.4.3)~~	~~—~~	~~#~~	~~#~~	~~X~~	~~X~~
~~Authorized personnel (4.4.4)~~	~~—~~	~~—~~	~~—~~	~~X~~	~~X~~
~~Alignment procedures (4.4.5)~~	~~—~~	~~X~~	~~X~~	~~X~~	~~X~~
~~Protective equipment (4.6)~~	~~—~~	~~—~~	~~—~~	~~#~~	~~X~~
~~Spectator control (4.4.6)~~	~~—~~	~~—~~	~~—~~	~~#~~	~~X~~
~~Service personnel (4.4.7)~~	~~**~~ ~~MPE~~	~~**~~ ~~MPE~~	~~**~~ ~~MPE~~	~~X~~	~~X~~
~~Demonstration with general public (4.5.1)~~	~~MPE~~ ~~(a)~~	~~X~~	~~X~~	~~X~~	~~X~~
~~Laser optical fiber systems (4.5.2)~~	~~MPE~~	~~MPE~~	~~MPE~~	~~X~~	~~X~~
~~Laser robotic installations (4.5.3)~~	~~—~~	~~—~~	~~—~~	~~X~~ ~~NHZ~~	~~X~~ ~~NHZ~~
~~Eye protection (4.6.2)~~	~~—~~	~~—~~	~~—~~	~~#~~ ~~MPE~~	~~X~~ ~~MPE~~
~~Protective windows (4.6.3)~~	~~—~~	~~—~~	~~—~~	~~X~~ ~~NHZ~~	~~X~~ ~~NHZ~~
~~Protective barriers and curtains (4.6.4)~~	~~—~~	~~—~~	~~—~~	~~#~~	~~#~~

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Skin protection (4.6.6)	---	---	---	X MPE	X MPE
Other protective equipment (4.6.7)	Use may be required				
Warning signs and labels (4.7) (Design requirements)	---	#	#	X NHZ	X NHZ
Service and repairs (4.4.7)	LSO determines				
Modifications and laser systems (4.1.2)	LSO determines				

LEGEND: X – required; # – recommended; --- – not required; ** – required if embedded Class 3B or Class 4; MPE – required if MPE is exceeded; NHZ - NHZ analysis required; (a) – Applicable only to ultraviolet and infrared lasers (4.5.1.2); (4.4.5) – referenced paragraph from ANSI Z136.1-2000

Administrative and Procedural Control Measures	Classifications						
	1	1M	2	2M	3R	3B	4
Standard Operating Procedures (4.4.1)	--	--	--	--	--	●	X
Output Emission Limitations (4.4.2)	--	--	--	--	LSO Determination		
Education and training (4.4.3)	--	●	●	●	●	X	X
Authorized Personnel (4.4.4)	--	*	--		--	X	X
Alignment Procedures (4.4.5)	Δ	Δ	Δ	Δ	Δ	X	X
Protective Equipment (4.6)	--	*	--	*	--	●	X
Spectators (4.4.6)	--	*	--	*	--	●	X
Service Personnel (4.4.7)	Δ	Δ	Δ	Δ	Δ	X	X
Demonstration with the General Public (4.5.1)	--	*	X	*	X	X	X
Laser Optical Fiber Transmission Systems (4.5.2)	MPE	MPE	MPE	MPE	MPE	X	X
Laser Robotic Installations (4.5.3)	--	--	--	--	--	X NHZ	X NHZ
Protective Eyewear (4.6.2)	--	--	--	--	--	●	X
Window Protection (4.6.3)	--	--	--	--	--	X	X NHZ
Protective Barriers and Curtains (4.6.4)	--	--	--	--	--	●	●
Skin Protection (4.6.6)	--	--	--	--	--	X	X NHZ
Other Protective Equipment (4.6.7)	Use may be required						
Warning Signs and Labels (4.7)	--	--	●	●	●	X	X

(Design Requirements)						NHZ	NHZ
Service Personnel (4.4.7)	LSO Determination						
Laser System Modifications (4.1.2)	LSO Determination						

LEGEND: X Shall
● Should
-- No Requirement
Δ Shall if enclosed Class3B or Class 4
MPE Shall if MPE is exceeded
NHZ Nominal Hazard Zone analysis required
* May apply with use of optical aids

6. Requirements for software that controls lasers

Software that controls lasers shall:

a. Provide safety precautions for fast moving-lasers and prevent misdirected lasers.

b. Undergo a hazard analysis as described in Chapter 2.4, "Hazard Analysis," of this handbook and NASA-STD-8719.13, "Software Safety."

7. Requirements for laser enclosures

In addition to laser enclosure requirements in paragraph 4 above, you shall:

a. Use flame-resistant materials or commercial products designed for laser enclosures to enclose Class 4 lasers. Laser levels above 10 watts per square centimeter could set the enclosure materials on fire.

b. Enclose high-pressure arc lamps and filament lamps or laser welding equipment in housings that can withstand the maximum pressure of a lamp explosion or disintegration.

c. Enclose laser targets and optical elements that could shatter during laser operation.

8. Protective equipment for operating a laser

If engineering controls don't eliminate the possibility of overexposure, you shall wear the following protective equipment:

a. Protective glasses or goggles designed to protect you from the laser you are using. Different lasers require different kinds of glasses or goggles. Make sure your protective glasses or goggles are on before you turn on the laser.

b. Skin protection as required.

Note: See ANSI Z136.1 for more details.

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9. Training required for laser operations

The JSC Laser Safety Officer determines what, if any, training and experience is commensurate with the laser hazards accessible at each facility. The JSC Laser Safety Officer designates all Area Laser Safety Officers (ALSOs) and certifies all laser operators (LOs). Training Categories are:

a. *Laser operator* – The training and experience required for a certified LO may include, but is not necessarily limited to, the laser training topics as seen in ANSI Z136.1, "Safe Use of Lasers," Appendix D6.2 (1). LOs are required to have initial and refresher training every 2 years thereafter. Training will be documented and maintained by the LO and the JSC LSO. A card will be issued for each laser operator certified by the JSC Laser Safety Officer.

b. *Area laser safety officer* – The training and experience required for an ALSO may include, but is not necessarily limited to, the laser training topics as seen in ANSI Z136.1, "Safe Use of Lasers," Appendix D6.2 (1) and (2). ALSOs are required to have an initial 40 hours of classroom training and refresher training every 2 years thereafter. Training will be documented and maintained by the ALSO and the JSC LSO.

c. *Peripheral personnel (janitors, security, firefighters, waste handlers, etc.)* – The ALSO and the LO are responsible for initial awareness-level laser safety training of peripheral personnel in their area such that they (peripheral personnel) understand the laser hazards associated with their work and are able to take appropriate actions to prevent unnecessary exposure. Awareness-level training shall be documented and a card issued for each person so trained by the JSC Laser Safety Officer. Refresher training is required every 3 years.

d. In addition to the above training categories and topics, you shall be certified to operate a laser as described in Chapter 5.8 of this handbook.

10. Emergency actions for laser mishaps

If laser mishap occurs, follow the emergency procedures in Chapter 3.8, "Emergency Preparedness," of this handbook and the emergency procedures for your facility. You shall contact the LSO as soon as possible to help you investigate the mishap.

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11. Outdoor laser operations

The American National Standard Z136.6 provides guidance for the safe use of potentially hazardous lasers and laser systems (0.18 µm to 1 mm), in an outdoor environment. Beams directed into airspace may require coordination with FAA and possibly the U.S. Space Command Laser Clearinghouse.

Chapter 6.6
Underwater operations safety and health

This could be you . . .

A scuba diver was working upside-down for about 45 minutes when he noted a slight chest pain. The diver was treated for medistanal emphysema and returned to diving after 2 weeks.

During a free-dive training exercise, a dive instructor suffered from shallow water blackout. A dive student retrieved the instructor from the pool bottom. Surface observers performed cardiopulmonary resuscitation on the dive instructor.

1. Applicability of this chapter

You are required to follow this chapter if you operate or work with neutral buoyancy facilities, plan open water training, or use other non-open-water facilities.

2. What this chapter covers

This chapter covers dive operation for open and non-open-water diving. It includes the following:

a. Underwater testing and training

b. Dive standards

c. Requirements for divers, equipment, and breathing gases

d. General operating procedures

3. Open and non-open-water diving

For the purpose of this chapter, non-open-water diving is conducted in water that is in a manmade enclosure and is treated with chemicals.

Non-open water diving

4. Steps to follow when using a neutral buoyancy facility

As a test requester or operator, you shall:

a. Follow Chapter 6.9, "Space systems and test safety," of this handbook for training and testing operations in JSC neutral buoyancy facility (NBFs).

b. Follow the requirements in NASA-STD-8719.10, "Standard for Underwater Facility and

Non-Open Water Operations."

c. Develop a dive plan that includes the following at a minimum:
   1. Purpose of the test.
   2. Test objectives.
   3. Scope of the test.
   4. Test requirements.
   5. Safety and medical planning provisions.
   6. Any known medical issues.
   7. Any special precautions or safety considerations.
   8. Method of testing.
   9. Other items that might be required by the NBF you are using.
   10. The NBF's critical lift procedures.

The NBF may have more requirements than those listed here.

Open water diving

5. Requirements for open water operations

If you, as a test requester, are involved with human open-water testing or training, you make your management, the Safety and Test Operations Division, and the Occupational Health Branch aware of your intentions.

6. Standards for open water operations

You shall:

a. Follow 29 CFR 1910, Subpart T, "Commercial Diving Operations."

b. Develop alternate standards if your operations involve unique equipment and methods not addressed by OSHA. These standards shall be:
   1. Developed by the responsible line management.
   2. Based on consensus standards.
   3. Approved as described in Chapter 1.4, "Written Safety and Health Program," of this handbook.

Other requirements that apply to open and non-open water diving

7. Using the "buddy system"

As a diver, you shall use the "buddy system." Never dive alone unless all of the following are true:

a. There is an emergency and someone's life is in danger.

b. You volunteer for the rescue. No one may force you.

c. You are in direct visual contact or are tethered.

8. Medical requirements for dive team members during a test

You shall have a medical examination:

a. At least yearly by a doctor who knows the hyperbaric conditions that you will encounter, your mode of diving, and what type of work you will be doing. If you are a guest diver, you shall have an examination at least ~~every 3~~ yearly~~s~~.

b. Before diving.

c. If you are injured or become ill and have to be hospitalized for more than 24 hours.

d. At the attending doctor's discretion.

9. Training for dive team members

You need to be certified as described in Chapter 5.8, "Hazardous operations: safe practices and certification," of this handbook. Your formal training shall include the following:

a. The use of the tools, equipment, and systems that you will use.

b. Techniques and procedures of the assigned diving modes, including the buddy system concept and open water communication.

c. Diving operations, including diving-related physics and physiology.

d. Emergency procedures, including cardiopulmonary resuscitation and first aid for lifeguards only.

10. Minimum requirements for breathing gases and diving equipment

Breathing gases and equipment used in NBFs shall meet these minimum requirements of Chapter 6.13, "Safety and Health Requirements for Ground-Based Breathing Gases and Breathing Gas Systems," of this handbook. Document and correct all discrepancies that you find in the equipment before you use it on any more dives.

11. Electrical equipment for underwater use

You shall follow these requirements for electrical equipment used underwater:

a. Tools and underwater equipment shall meet the minimum electrical requirements contained in this section of NASA-STD-8719.10, or be accepted for use by an ad hoc committee composed of representatives of the Center's safety, underwater facility line management, medical, and electrical engineer with bio-electrical experience. The special ad hoc committee:

   1. Shall assess the shock hazard, recommend controls to reduce or eliminate the hazard, and discuss the risk associated with any remaining hazards.

   2. Shall present its results to the appropriate Test Readiness Review Board (TRRB) for approval.

b. You are responsible for safeguard batteries used underwater to prevent hydrogen outgassing, and packaging them to prevent chemical leakage into the water or electric short circuits from water leaks.

c. You shall protect personnel from exposure to any electrical hazard that can result in injury, created by underwater tools and equipment, by at least two independent verifiable controls. Controls need to be verified operational before use. The potential for exposure to electric currents greater than or equal to 6.0 milliamperes represents a potential electric hazard.

d. The special ad hoc committee mentioned in subparagraph 11.a above shall review tools, equipment, or systems using greater than 30 volts (alternating current (AC) (root mean square), direct current (DC), or combination) and present the results to the TRRB for approval before use in the underwater facility. Tools and underwater equipment limited to 30 volts or less (AC (rms), DC, or combination thereof) that include a verifiable barrier to electric shock are not normally considered potentially hazardous.

e. You shall install listed ground fault circuit interrupters in the branch circuit supplying underwater lighting fixtures operating at more than 15 volts AC so that there is no shock hazard during re-lamping.

f. Areas around the pool that are subject to saturation with water or other liquids shall be considered "wet area locations" and protected with listed ground fault circuit interrupters in the branch circuits.

12. General operating procedures

If you oversee any diving operations, you need to have a "safe practices manual" available to each dive team member at the open water dive location. The manual shall include standards, general information, requirements, and:

a. Specific procedures and checklists for each diving operation. See paragraph 14 below for minimum requirements.

b. Responsibilities of the dive team members and support personnel.

c. Equipment procedures and checklists.

d. General emergency procedures, including rescue techniques and medical treatment.

13. What the general operating procedures need to cover for each dive phase

Follow these requirements:

a. The pre-dive phase shall include:

1. Planning the dive.
2. Assessing the safety of the dive.
3. Identifying and inspecting equipment and supplies.

b. The dive phase shall include:

1. Entering and exiting the water.
2. Communications between divers and surface personnel.
3. Dive profiles and limits.
4. Individual and crew responsibilities.
5. Decompression tables as appropriate.
6. Tools and equipment.
7. Use of hazardous materials.
8. Dive termination under normal and emergency conditions.
9. Use of support and rescue equipment.

c. The post-dive phase shall include:

1. Checks on physical conditions of the divers.
2. Other precautions necessary following the dive.
3. Preparation of records of the dive.
4. Records of equipment malfunctions.
5. If required, assessment of recompression capability and decompression procedure.

14. Pre-dive briefing

Before the dive you need to have a diver and crew briefing by a person familiar with the safety requirements and operational aspects of the dive. The briefing shall include a review of the following:

a. The applicable portions of the safe practices manual.

b. The specific operating procedures and individual diver and responsibilities.

c. Dive profiles and operational limits.

d. The buddy system (no one dives alone), assignments of pairs, and communications.

e. Emergency and rescue procedures and responsible personnel.

15. Records

You shall keep the following records, make copies available for employees to review, and protect them under the Privacy Act of 1974:

a. Records, reports, and other documents pertinent to the safety and health of employees in open water operations. You shall prepare and maintain them under an established schedule that includes at least the requirements in OSHA 29 CFR 1910.440, "Record Keeping Requirements."

b. Breathing air records, such as sampling and analysis results.

c. Records of all maintenance on the diving equipment and support apparatus.

d. Records of all materials used in an oxygen-enriched environment if enriched gas mixtures are used.

16. Responsibilities for underwater safety

The following have responsibilities for underwater safety:

a. If you are a ***line manager***, you are responsible for making sure that the regulations in this handbook and applicable OSHA regulations are met.

b. The ***Safety and Test Operations Division*** is responsible for:

1. Making sure that human testing, training, or preparations follow the regulations in this handbook, applicable OSHA regulations, and approved procedures.

2. Monitoring all suited subject testing or training. The Safety and Test Operations Division may decide to monitor other testing or training.

c. The ***Medical Operations Branch*** is responsible for:

1. Monitoring all human testing or training based on the requirements of NASA-STD-8719.10.

2. Making sure that the people involved in open water operations meet the physical requirements to perform their duties.

Chapter 6.11
Pressurized Gas and Liquid Systems

This could be you . . .

A technician was burned by a fire in a component of a high-pressure oxygen system.

An expansion bellows on a section of piping ruptured during pressure testing and injured several employees. The bellows wasn't properly restrained during the testing.

A gate valve on a high-pressure nitrogen trailer flew off and killed an employee during maintenance. The maintenance workers didn't take all possible steps to make sure that the trailer wasn't pressurized before working on it.

1. Applicability of this chapter

You are required to follow this chapter if you use pressurized gas or liquid systems.

2. Requirements for using any pressurized systems

All your pressure vessels, pressure systems, and pressure systems components shall:

a. Be designed, installed, tested, certified, and periodically recertified to the requirements of JPR 1710.13, "Design, Inspection, and Certification of Pressure Vessels and Pressurized Systems" (current version).

b. Have their current design, installation, testing, certifications, modifications, periodic recertifications, and maintenance properly documented.

c. Be marked, tagged, or otherwise identified to indicate the certified use.

d. Be located to minimize the risk to personnel and surrounding equipment and facilities if a leak or rupture occurs.

3. Requirements for systems that contain pressure vessels, fixed piping or tubing, valves, or other components

Your pressure systems shall:

a. Meet JPR 1710.13 (current version) for the design, installation, testing, certification, and periodic recertification of your pressure vessel.

b. Meet American Institute of Aeronautics and Astronautics (AIAA) Guide 095-2004, "Guide to Safety of Hydrogen and Hydrogen Systems," specifications if your pressure system contains hydrogen.

c. Make sure that relief valves and other discharge parts follow minimum separation distances as called out in the references given above.

d. Properly restrain relief valves, rupture discs, burst discs, and associated piping or tubing to prevent movement from the thrust created by a pressure release.

e. Properly bond and ground your systems.

4. Requirements for fire protection systems

All fire protection systems shall meet the requirements of the NFPA for the specific type of fire protections system involved.

5. Requirements for flex hoses

You shall meet the following requirements:

a. Proof pressure-test and tag flex hoses according to the requirements of JPR 1710.13 (current version).

b. Secure flex hoses that are not in a cabinet or other containment and that are used in 150-psig or greater normal service at both ends and tether or weigh them down at no greater than 6-foot intervals, and you shall:

1. Secure hoses between 3 and 6 feet in length at both ends and tether or weigh them down in the middle. Hoses shorter than 3 feet in length only need to be secured at both ends.

2. Ensure that this securing, tethering, or weighting is sufficient to withstand forces arising from sudden failure. Strapping hoses together is considered tethering.

3. Secure flex hose vent and drain lines at the free end.

c. Flex hoses need not be secured if in vacuum service or a written hazard analysis or technical order, which controls the hazard, is approved Safety and Test Operations Division.

6. Requirements for systems using oxygen or oxygen-enriched gas (greater than 25 mole percent oxygen or oxygen greater than 25% oxygen by volume)

You shall meet the following requirements:

a. Oxygen systems shall meet NASA-STD-6001, "Flammability, Odor, Off-Gassing and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion." Use ASTM MNL36, "Manual for Safe Use of Oxygen Systems: Guidelines for Oxygen System Design, Materials Selection, Operations, Storage, and Transportation," as a guide.

b. For systems using oxygen or oxygen-enriched gas above 250 psi and that involve humans in the loop, you need to flow the oxygen through the system unmanned before introducing a human into the system. Examples of these systems include chambers and breathing gas systems. Testing shall follow these requirements:

1. Test new systems and test, after modifications, existing systems that require disassembly and reassembly of the parts of the system.
2. Test the system at maximum operating pressure (just below relief valve pressure) for 10 cycles.
3. Sample for chemical purity per MIL-PRF-27210G. Also test moisture levels per specific program requirements. Sample the system before use, or monthly and after any maintenance activities that violate system integrity.

7. Requirements for using compressed gas

You shall meet all the requirements of 29 CFR 1910.101, "Compressed Gas Cylinders."

The Logistics Division is the only authorized avenue for obtaining gases for use at JSC, Ellington Field, and SCTF, including gases used by onsite contractors. For safety and accountability, NASA and vendor owned cylinders are tracked, disposed of, and/or returned to vendors when no longer required. Any unauthorized gas purchases will be held in the hazardous storage area and may be returned to the vendor. As an authorized user of compressed gas cylinders, you shall:

a. Send gas requests to JB3/Lois Hayman on a JSC Form (JF)1710, JSC Warehouse Requisition, or fax to 46540.

b. Contact JB3/Lois Hayman (CSC) at extension 36547 for pickup of cylinders that are empty or no longer needed.

c. Ensure that JSC Form 1161 accompanies cylinders that contain hazardous material (A compressed gas container is empty if at atmospheric pressure)

8. For more information on pressurized gases and liquids

You can find more information on pressure systems in the following:

a. 29 CFR 1910.101

b. JPR 1710.13 (current version)

c. NASA-STD-6001, "Flammability, Odor, Off-Gassing and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion"

d. ASTM MNL36, "Manual for Safe Use of Oxygen Systems: Guidelines for Oxygen System Design, Materials Selection, Operations, Storage, and Transportation"

e. AIAA Guide 095-2004, "Guide to Safety of Hydrogen and Hydrogen Systems"

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